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RESEARCH ARTICLE

A new species of *Cellaria* (Bryozoa: Cheilostomata) from northeastern Brazil, with a tabular identification key to the Atlantic species

Ana C.S. Almeida[1,2], Facelúcia B.C. Souza[2], Leandro M. Vieira[1]

[1]*Laboratório de Estudos de Bryozoa, Departamento de Zoologia, Centro de Biociências, Universidade Federal de Pernambuco. 50670-810 Recife, PE, Brazil.*
[2]*Museu de Zoologia, Universidade Federal da Bahia. 40170-115 Salvador, BA, Brazil.*
Corresponding author: Ana Carolina S. Almeida (carol.salmeida@gmail.com)

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ABSTRACT. A new species of the erect cheilostome bryozoan *Cellaria* Ellis & Solander, 1786 is described from Bahia, NE Brazil. *Cellaria oraneae* **sp. nov.** is the first formally characterized species of the genus reported from Northeastern coast of Brazil, distinguished from all congeners by the combination of hexagonal autozooids and rhomboid fertile zooids, hexagonal interzooidal avicularium with sagittate foramen, completely immersed ovicell with oval aperture and proximal rectangular lip. A brief discussion of the diversity of *Cellaria* from the Atlantic Ocean and a tabular identification key to these species are also provided.

KEY WORDS. Bryozoan, Cellariidae, taxonomy, Western Atlantic.

INTRODUCTION

Marine bryozoans are found in all oceans, from the intertidal to abyssal depths. The vast majority of some 5,689 living species (Bock and Gordon 2013) belongs to Order Cheilostomata Busk, 1852, which shows a wide variety of colonial growth forms, from encrusting laminar to erect colonies (Taylor and James 2013). Encrusting colonies seem to be more abundant in tropical regions, whereas erect bryozoans are particularly diverse in temperate and polar waters. (Barnes and Whittington 1999, Taylor and James 2013).

Among the erect bryozoans, *Cellaria* Ellis & Solander, 1786 is a speciose genus, comprising more than 50 living species (Hayward and Thorpe 1989, Bock and Hayward 2014). Colonies have articulated skeletal elements (internodes) joined by chitinous joints, with each internode containing multiple zooids (Taylor and James 2013). *Cellaria* species may occur from less than 20 to over 1000 m deep in all oceans. They are common in shallow, coastal waters, attached to hard substrata (McKinney and Jaklin 2000, 2001, Hayward and McKinney 2002). Most *Cellaria* are known from the Indo-Pacific regions, Antarctica and Northeast Atlantic, being apparently limited to their expected native distribution (Hayward and Thorpe 1989). Only a few species have been documented from the Western Atlantic (Winston and Woollacott 2009, Bock and Hayward 2014). However, in the past few years, five new species were described from this region – *Cellaria brasiliensis* Winston, Vieira & Woollacott, 2014, *Cellaria riograndensis* Ramalho & Calliari, 2015 and *Cellaria subtropicalis* Vieira, Gordon, Souza & Haddad, 2010 from Brazil; *Cellaria novanglia* Winston & Hayward, 2012 and *Cellaria louisorum* Winston & Woollacott, 2009 from United States and Barbados, respectively. This indicates that the diversity of *Cellaria* from the Atlantic is yet to be described.

Over the past decade, knowledge of the diversity of marine bryozoans in Brazil has grown significantly and more than 100 new species were described (e.g., Vieira et al. 2010, 2012, 2014, Winston and Vieira 2013, Winston et al. 2014, Almeida et al. 2015a, Ramalho and Calliari 2015). Although *Cellaria* have been documented in the Brazilian waters since the 1960s (Braga 1967, Vieira et al. 2008), the first species from Brazil, *C. subtropicalis*, was only recently formally characterized and described (Vieira et al. 2010). Since then, two other new species were described, *C. brasiliensis* from Rio de Janeiro (Winston et al. 2014), and *C. riograndensis*, from Rio Grande do Sul (Ramalho and Calliari 2015). These three valid species from the Brazilian coast are from South and Southeastern Brazil, and there is a record of a new species from Bahia (Vieira et al. 2008, Almeida et al. 2015b). This species was named *Cellaria bahiensis* in a doctoral dissertation but

never formally described (Vieira et al. 2008). Therefore, according to the International Code of Zoological Nomenclature Article 9.7 and Article 11.1 (ICZN 1999), the name *Cellaria bahiensis* Souza is a *nomen nudum* and cannot be considered valid, as pointed by Vieira et al. (2008).

Here we formally describe this new taxon from state of Bahia, Northeast Brazil, and provide a diagnosis for it based on specimens from the same locality (i.e. Todos os Santos Bay) as those studied by Souza (Vieira et al. 2008).

MATERIAL AND METHODS

All type and non-type specimens analyzed in this study are deposited in the Museu de Zoologia of Universidade Federal da Bahia (UFBA), Salvador, Brazil. The specimens were collected by dredge in different localities between 1997 and 2006 along the coast of Bahia, northeast Brazil, from 15 to 50 m (Fig. 1). Some specimens were collected by Laboratório de Malacologia e Ecologia de Bentos (LAMEB) from Universidade Federal da Bahia (UFBA) on different years but at the same locality, and were deposited in a single lot for each locality. Selected specimens were coated with gold-palladium alloy and examined under a scanning electron microscopy (JEOL JSM-6390LV) at Centro de Pesquisa Gonçalo Moniz (FIOCRUZ/BA), Bahia, Brazil. Measurements were taken from digital SEM images of the holotype using ImageJ® software, including range (minimum and maximum), mean, and standard deviation.

TAXONOMY

Order Cheilostomata Busk, 1852
Suborder Neocheilostomina d'Hondt, 1985
Cellariidae Fleming, 1828
Cellaria Ellis & Solander, 1786

Cellaria oraneae sp. nov.

http://zoobank.org/12CFEE7B-49C3-499A-8DEF-9BE90977492F
Figs 2–7

Cellaria sp. 2: Vieira et al. 2008: 21. [Brazil: Bahia]
Cellaria sp.: Almeida et al. 2015a: 4. [Brazil: Bahia]

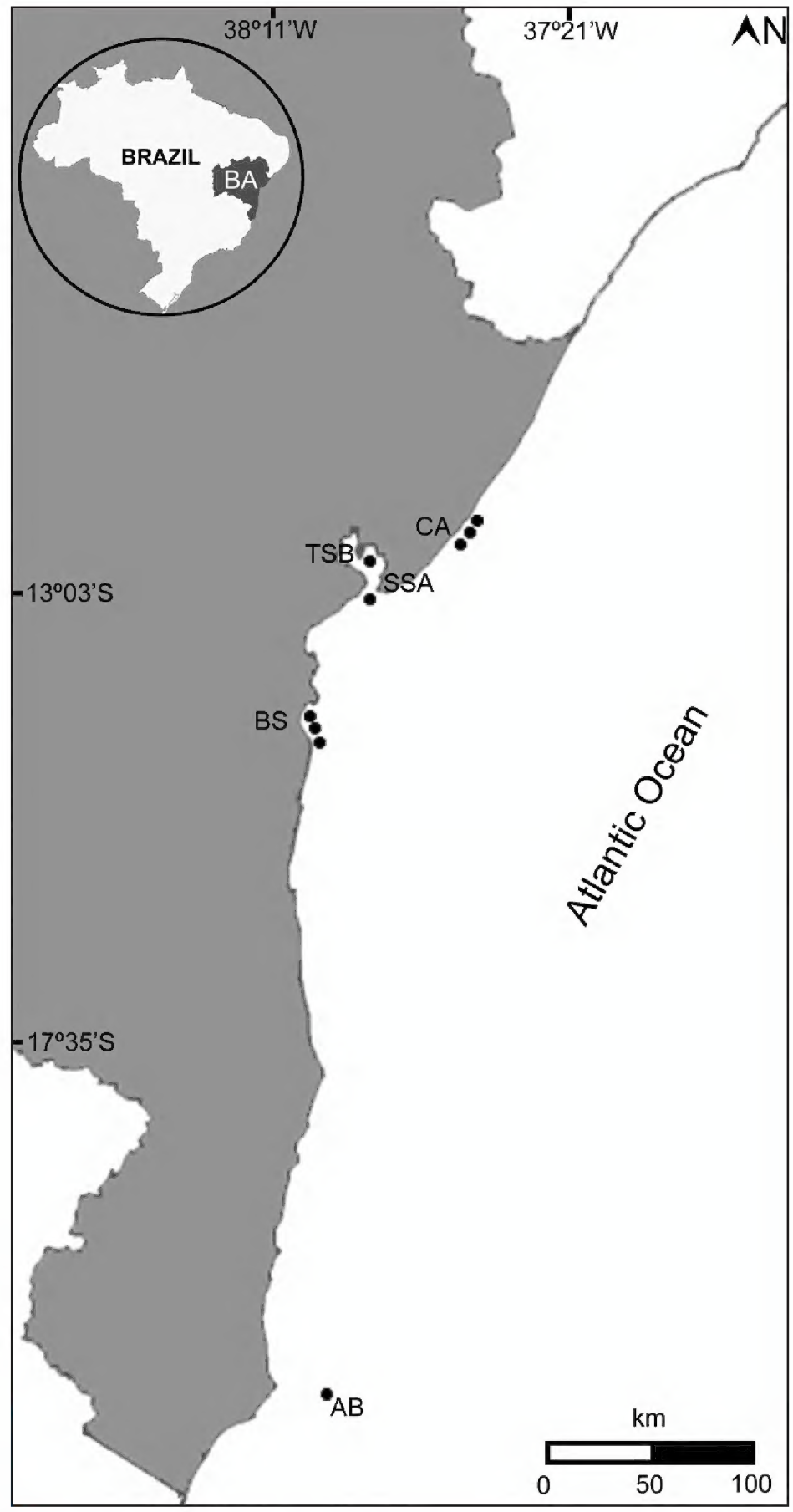
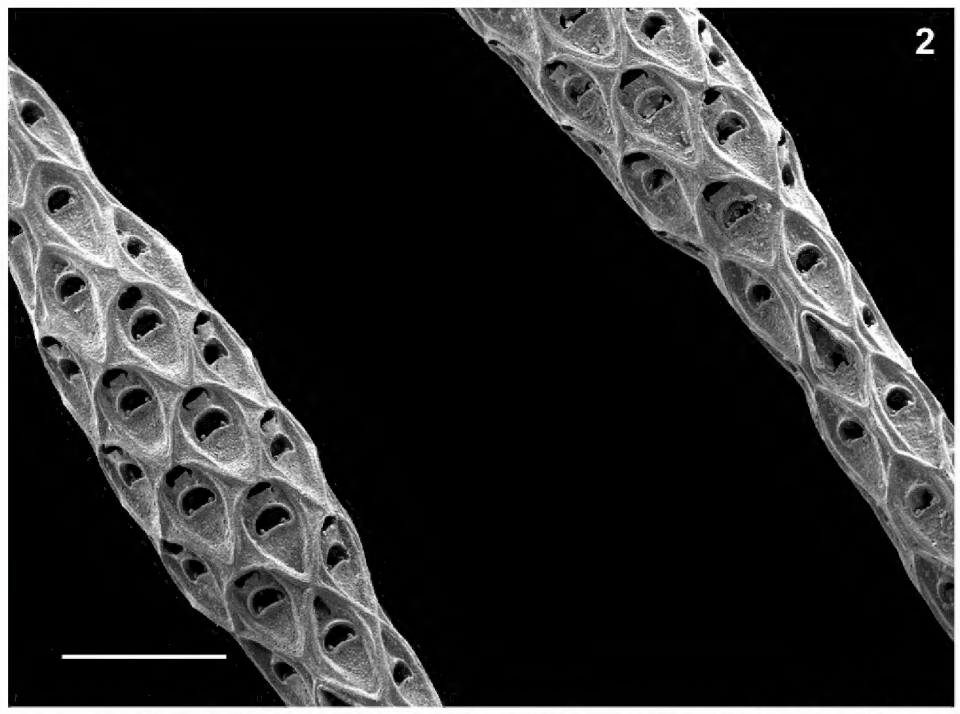
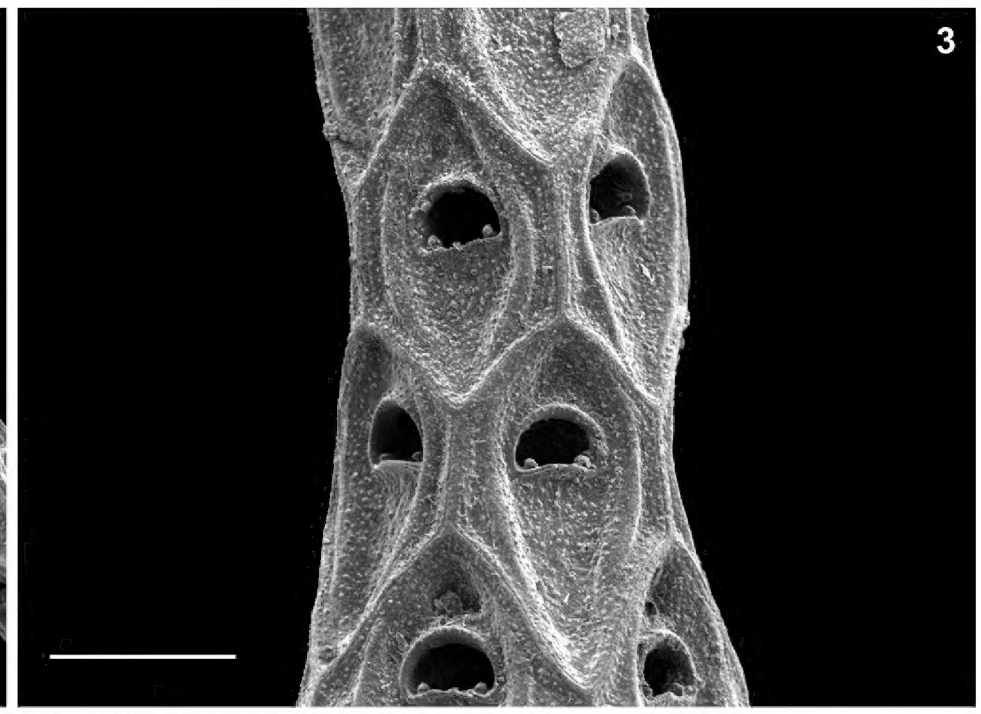


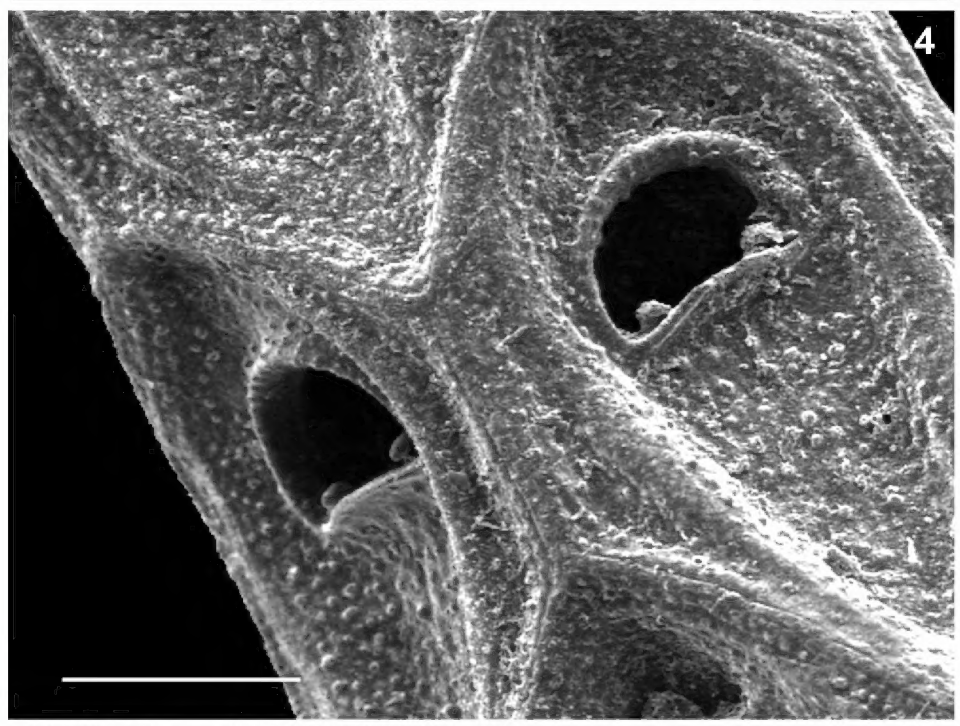
Figure 1. Distribution map of *Cellaria oraneae* sp. nov. in state of Bahia, northeast Brazil. (BA) Bahia, (CA) Camaçari, (SSA) Salvador, (TSB) Todos os Santos Bay, (BS) Baixo Sul, (AB) Abrolhos Bank.

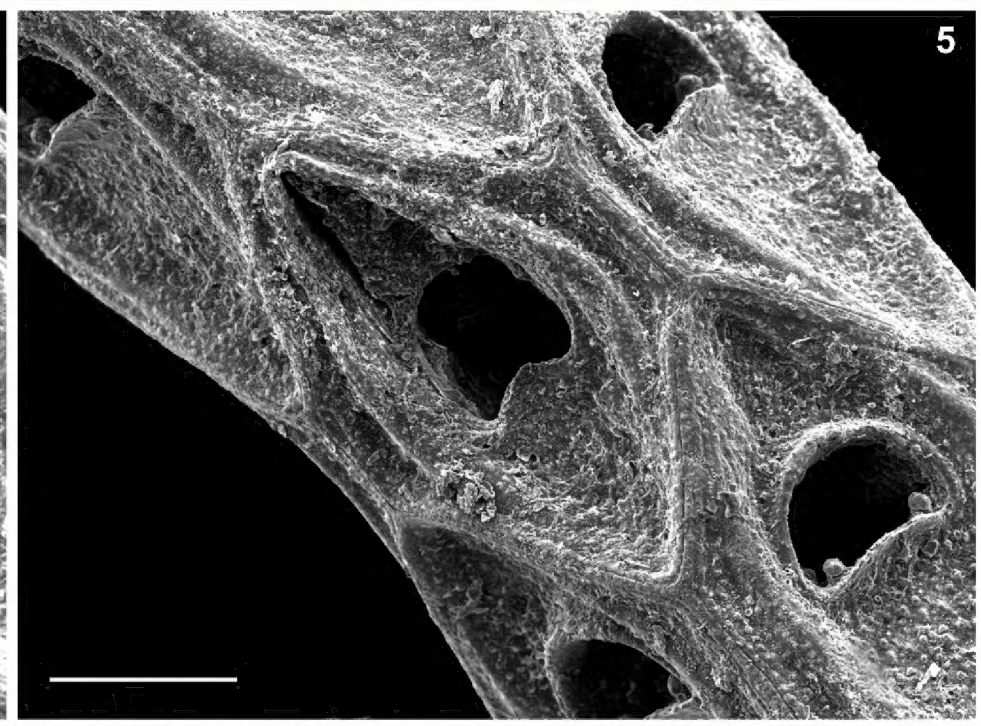
Diagnosis. *Cellaria* with hexagonal autozooids, opesia semi-elliptical with distal rim tuberculate and slightly convex proximal rim with two rounded condyles; interzooidal avicularia hexagonal, with longitudinal ridges forming a spear-shaped area, with sagittate foramen and placed only between non-fertile zooids; fertile zooids rhomboid and ovicell completely immersed with oval aperture and a proximal rectangular lip.

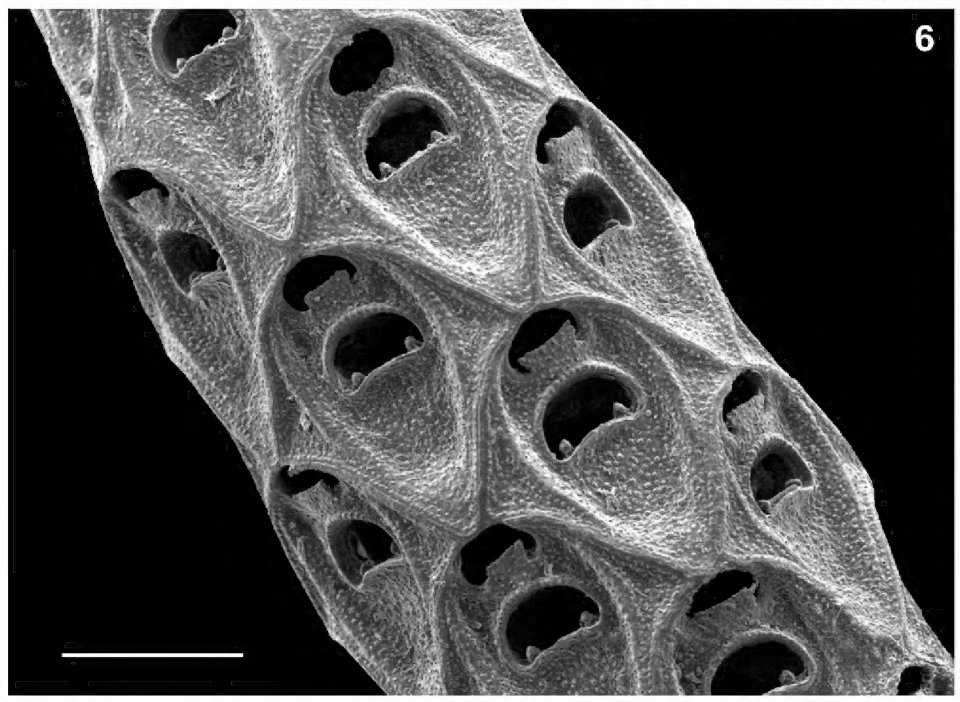
Description. Colony erect, cylindrical, jointed, symmetrically bifurcating and attached at the base by chitinous rhizoids. Branches formed by 6–20 zooidal series, 0.353–0.372 mm in diameter when formed only by infertile autozooids, but larger in regions of fertile zooids, about 0.544–0.574 mm in diameter (Fig. 2). Autozooids hexagonal in outline, about 0.358–0.409 mm (0.395 ± 0.016) long and 0.164–0.231 mm (0.211 ± 0.019) wide, limited by raised lateral walls, comprising a pair of longitudinal ridges extending from lateral walls forming a somewhat lanceolate area (Fig. 3). Frontal wall with a sunken granular cryptocyst. Opesia semi-elliptical, about 0.056–0.068 mm (0.62 ± 0.003) long and 0.072–0.095 mm (0.085 ± 0.006) wide, distal rim tuberculate and arched, proximal rim smooth

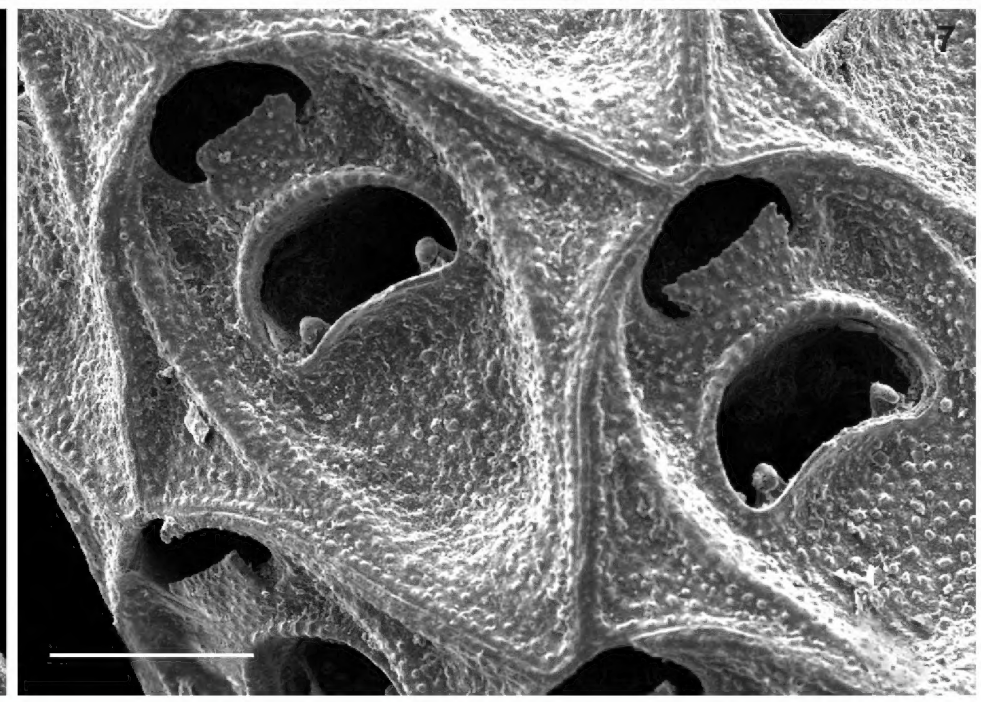












Figures 2–7. *Cellaria oraneae* sp. nov., UFBA 280, holotype, Bahia, Brazil: (2) general aspect of the branches; (3) close-up of subhexagonal autozooids; (4) close-up of opesia showing tuberculate distal rim and proximal condyles; (5) close-up of hexagonal interzooidal avicularia with longitudinal ridges forming a spear-shaped area and sagittate foramen; (6) close-up of fertile rhombic zooids; (7) close-up of immersed ovicells showing oval aperture with proximal rectangular lip. Scale bars: 2 = 500 µm; 3, 6 = 200 µm; 4, 5, 7 = 100 µm.

and slightly convex, two rounded denticles placed near proximal corners (Fig. 4). Interzooidal avicularium sometimes present, about 0.340–0.367 mm (0.354 ± 0.010) long and 0.186–0.210 mm (0.198 ± 0.009) wide, with same cryptocystal calcification and longitudinal ridges as autozooids, forming a spear-shaped area; foramen sagittate, tapered distal edge, convex proximally, forming a broad lip, placed only between infertile zooids (Fig. 5). Fertile zooids wider than autozooids, rhomboid in outline, about 0.316–0.374 mm (0.355 ± 0.016) long and 0.200–0.320 mm (0.285 ± 0.038) wide; opesia semi-elliptical, about 0.050–0.069 mm (0.60 ± 0.004) long and 0.078–0.115 mm (0.103 ± 0.009) wide, same cryptocystal calcification and longitudinal ridges as autozooids (Fig. 6). Ovicells completely immersed, aperture oval with a proximal rectangular lip (Fig. 7).

Material examined. Holotype: Brazil, *Bahia*: Todos os Santos Bay (12°51'62"S, 38°39'78"W, 43 m), 1 specimen, April 1997, Orane Alves leg., UFBA 280. Paratypes: Brazil, *Bahia*: Todos os Santos Bay (12°49'62"S, 38°37'38"W), 1 specimen, May 1997, Orane Alves leg., UFBA 2263; Salvador (12°58'79"S, 38°33'41"W, 50 m), 1 specimen, UFBA 2262. *Additional specimens*: Brazil, *Bahia*: Abrolhos Bank (18°20'80"S, 38°55'97"W, 41 m), 10 specimens, April 1997, Zelinda Leão leg., UFBA 1446; Maraú (Baixo Sul, 14°06'49"S, 38°57'31"W), 5 specimens, August 2004, LAMEB-UFBA leg., UFBA 2261; Cairú (Baixo Sul, 13°27'01"S, 38°46'34"W, 48 m), 2 specimens, 2002, José Dominguez leg., UFBA 2260; Ituberá (Baixo Sul, 13°44'02"S, 38°48'58"W, 47 m), 6 specimens, 2002, José Dominguez leg., UFBA 2259; Maraú (Baixo Sul, 14°05'00"S, 38°53'55"W, 30 m), 6 specimens, 2002, José Dominguez leg., UFBA 2258; Itacaré (Baixo Sul, 14°11'01"S, 38°58'59"W, 15 m), 8 specimens, 2002, José Dominguez leg., UFBA 2241; Camaçari (12°44'12"S, 38°05'12"W, 23 m), 4 specimens, 2002-2004, LAMEB-UFBA leg., UFBA 2257; Camaçari (12°50'00"S, 38°10'06"W, 37 m), 6 specimens, 2002-2006, LAMEB-UFBA leg., UFBA 2256.

Distribution. Atlantic: Brazil (Bahia); infralittoral, from 15 to 50 m.

Etymology. The species epithet is in honor of Orane Alves (Universidade Federal da Bahia), in recognition of her contribution to the knowledge of Brazil's marine biodiversity.

Remarks. *Cellaria oraneae* sp. nov. can be distinguished from all congeners by the combination of hexagonal autozooids and rhomboid fertile zooids, hexagonal interzooidal avicularia with longitudinal ridges forming a spear-shaped area and with sagittate foramen, ovicell completely immersed with aperture oval and a proximal rectangular lip. We analyzed 50 internodes of the new species, among which 30 were formed only by autozooids (infertile internodes) and 20 were fertile (with autozooids and ovicelled zooids). Avicularia were found in both fertile and infertile internodes, but no avicularia were found between fertile zooids. Therefore, we believe that interzooidal avicularia of *C. oraneae* sp. nov. are placed only between autozooids.

Among *Cellaria* species already recorded from the Atlantic Ocean, *C. oraneae* sp. nov. resembles *C. riograndensis* in having cryptocyst mostly granular, hexagonal interzooidal avicularia with longitudinal ridges forming a spear-shaped area, with no condyles and completely immersed ovicell. *Cellaria oraneae* sp. nov. can be distinguished from *C. riograndensis* by having autozooids hexagonal and fertile rhomboid zooids (in *C. riograndensis*, both autozooids and fertile zooids have the same shape), avicularia placed only between autozooids and with sagittate foramen (avicularia is placed between either autozooids and fertile zooids and with triangular foramen in *C. riograndensis*), and ovicell aperture with a proximal rectangular lip (without lip in *C. riograndensis*).

Among other *Cellaria* distributed worldwide, *C. oranae* sp. nov. resembles *C. tenuirostris* (Busk, 1852) in the hexagonal autozooids and rhomboid fertile zooids, granular cryptocyst, hexagonal interzooidal avicularia with longitudinal ridges forming a spear-shaped area and completely immersed ovicell. *Cellaria oranae* sp. nov. is distinct from *C. tenuirostris*, however, by having avicularium with sagittate foramen and no condyles (*C. tenuirostris* have an avicularium with triangular foramen and well-developed condyles), avicularium placed only between autozooids (in *C. tenuirostris* avicularia are placed between either autozooids and fertile zooids), and ovicell aperture with a proximal rectangular lip (without lip in *C. tenuirostris*).

DISCUSSION

The morphological characters commonly used to discriminate among *Cellaria* species include the shape of autozooids and fertile zooids (assigned as hexagonal when formed by six sides or rhomboid when with four sides; Hastings 1947), opesial condyles, type of avicularia and shape of its foramen, ovicell and its aperture. Species of *Cellaria* show a wide range of morphologies, which include species with condyles at the distal opesial rim or at both distal and proximal opesial rim; avicularium large, interzooidal (i.e. replacing one autozooid; Hayward and Ryland 1998) or small, fistulose-like (i.e. interposed in the longitudinal series of autozooids; Hayward and Ryland 1998 and Berning 2013); and ovicells slightly prominent or completely immersed, with aperture varying from a single entire fenestra or ornamented with a proximal lip. The foramen of the avicularia, either interzooidal or fistulose, shows several morphologies, including bell-shaped (i.e. forming an inverted U-shaped curve; López de La Cuadra and García-Gómez 1996); triangular (i.e. three sides with pointed tips); subtriangular (i.e. three sides with rounded edges); semicircular (i.e. as long as wide); semielliptical (i.e. longer than wide); subcordate (i.e. somewhat heart-shaped; López de La Cuadra and García-Gómez 1996); mushroom-shaped (i.e. resembling the profile of a mushroom; Winston and Hayward 2012) and sagittate (i.e. shaped like an arrowhead, Table 1). As known in other bryozoan genera (e.g., Vieira et al. 2013, Almeida et al. 2014), the analysis and characterization the morphology of the ovicell/ooecia are needed to make a taxonomic assignment. In the absence of fertile colonies, it is difficult to assign specimens to any known species using only autozooidal characteristics.

Table 1. Tabular identification key to Atlantic species of *Cellaria*: present (+) and absent (–), avicularia interzooidal (I), avicularia fistulose (F), unknown states (?).

Species	Autozooid		Opesia			Avicularia				Dimorphism in fertile zooid	Ovicell/Aperture
	Shape	Cryptocyst	Distal rim	Proximal rim	Distal condyles	Type	Shape	Foramen	Condyles		
C. atlantida Cook, 1967	rhombic	granular	beaded	convex	–	I	rhombic	bell-shaped	–	–	immersed/with rectangular lip
C. bassleri Hastings, 1947	rhombic	smooth	smooth	convex	–	I	hexagonal	subtriangular	–	–	immersed/ semicircular
C. bafouri Matsuyama, Titschack, Baum & Freiwald, 2015	hexagonal	smooth	beaded	convex	–	–	–	–	–	–	immersed/with rectangular lip
C. brasiliensis Winston, Vieira & Woollacott, 2014	hexagonal	granular	beaded	convex	–	I	hexagonal	subtriangular	+	–	immersed/oval to circular
C. clavata (Busk, 1884)	rhombic	granular	beaded	convex	+	F	semicircular	semicircular	–	+ (hexagonal)	immersed/ circular, with rectangular lip in later astogeny
C. cookae Lopez de la Cuadra & García-Gómez, 1996	hexagonal	granular	beaded	convex	–	I	hexagonal	subcordate	–	–	immersed/with rectangular lip
C. crassa Wood, 1844	hexagonal	granular	?	convex	+	I	rhombic	subtriangular	–	+ (rhombic)	immersed/ semicircular
C. diffusa Robertson, 1905	hexagonal	granular	beaded	convex	+	F	quadrangular	semicircular	–	–	immersed/oval
C. elongatoides Bassler, 1936	hexagonal	granular	?	convex	–	F	circular	semicircular	–	+ (with larger opesial condyles)	immersed/with semicircular lip
C. fistulosa (Linnaeus, 1758)	rhombic/ hexagonal	granular	beaded	convex	–	F	quadrangular to rounded	semielliptical	+	–	immersed/ circular, with rectangular lip in later astogeny
C. harmelini d'Hondt, 1973	hexagonal	smooth	beaded	convex	–	F	semicircular	semicircular	-	–	immersed/with rectangular lip
C. louisorum Winston & Woollacott, 2009	hexagonal	granular	beaded	convex	–	I	hexagonal	triangular	+	+ (with concave proximal rim)	immersed/circular
C. normani (Hastings, 1947)	hexagonal	granular	beaded	convex	–	I	hexagonal	semicircular	+	–	immersed/oval to circular
C. novanglia Winston & Hayward, 2012	hexagonal	granular	beaded	convex	–	F	quadrangular	mushroom-shaped	+	–	immersed/with rectangular lip
C. oraneae sp.	hexagonal	granular	beaded	convex	–	I	hexagonal	sagittate	–	+ (rhombic)	immersed/with rectangular lip
C. ornata d'Orbigny, 1842	rhombic	granular	beaded	convex	?	I	?	triangular	?	?	?
C. paradoxa Hayward & Cook, 1979	hexagonal	granular	smooth	convex	+	–	–	–	–	+ (rhombic, with larger opesia)	immersed/ semicircular
C. riograndensis Ramalho & Calliari, 2015	rhombic/ hexagonal	granular	beaded	convex	–	I	hexagonal	triangular	–	–	immersed/circular
C. salicornioides Lamouroux, 1816	hexagonal	granular	beaded	convex	+	I	hexagonal	semicircular	+	–	immersed/circular
C. scoresbyi Hastings, 1947	hexagonal	granular	beaded	convex	-	I	hexagonal	triangular	+	–	immersed/with rectangular lip
C. sinuosa (Hassall, 1840)	hexagonal	granular	smooth	straight	+	F	circular	semicircular	+	–	immersed/with rectangular lip
C. sobrionoi Lopez de la Cuadra & García-Gómez, 2000	hexagonal	granular	beaded	convex	–	I	rhombic	subtriangular	+	–	prominent/ triangular
C. subtropicalis Vieira, Gordon, Souza & Haddad, 2010	rhombic/ hexagonal	granular	beaded	convex	–	I	hexagonal	subtriangular	+	–	Immersed/ semielliptical to subtriangular
C. triangulata Canu & Bassler, 1925	rhombic	smooth	?	straight	–	?	?	?	?	+ (with larger opesia)	immersed/ triangular

At least 58 species of *Cellaria* are recognized worldwide (Bock and Hayward 2014). So far, 23 species have been recorded from the Atlantic Ocean and, among these, 12 from the Western Atlantic. *Cellaria oraneae* n. sp. is the fourth species of the genus described from Brazil, representing the only species from the Northeast. Since there are few studies on the continental shelf and slope of the Brazilian Northeast, where the genus seems to be common, it is likely that the diversity of *Cellaria* from Brazil has been underestimated. This seems to be the case with other Brazilian bryozoan taxa (e.g., Vieira et al. 2010, Almeida and Souza 2014, Winston et al. 2014, Almeida et al. 2014, 2015a). The real diversity of the genus around the world is also difficult to estimate,

since many records have been attributed to the widely-known *C. tenuirostris*, restricted to the Indo-Pacific Oceans (Hastings 1947, Winston 2005). Additionally, some species assigned to *Cellaria* are only known from their original descriptions (e.g., *Cellaria ornata* d'Orbigny, 1842, *Cellaria triangulata* Canu & Bassler, 1925). Without more recent morphological characterization or comparison with related taxa, the validity of some of these may be questionable. Comprehensive studies using SEM are still lacking, preventing the elucidation of the identity of some species as *Cellaria clavata* (Busk, 1884), *Cellaria salicornia* (Pallas, 1766) and *Cellaria normani* (Hastings, 1947) (Hastings 1947, Hayward and Thorpe 1989, López de La Cuadra and García-Gómez 1996). As pointed out by Cook (1967), a review of these taxa is recommended.

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